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The attainment of peak bone mass during the premenopausal years is critical in preventing osteoporosis later in life. The purpose of this study was to survey 1,000 active duty military premenopausal women in regards to skeletal health habits such as current levels of calcium intake, exercise, smoking, alcohol intake, menstrual regularity, and parity. We further wished to measure bone density in a subset of 100 women to determine which factors correlated best with optimal peak bone mass.

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Michael T McDermott COL MC
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25 June 1996
Date

TABLE OF CONTENTS

## Introduction

The attainment of maximal peak bone mass in the premenopausal years is important in the prevention of postmenopausal osteoporosis. Peak bone mass, which occurs at approximately age 25 years in women, appears to be an important determinant of the risk of developing postmenopausal osteoporosis. Three factors are considered major contributors to the development of peak bone mass: genetics, calcium intake and physical activity. Additionally a number of adverse risk factors including smoking, alcohol consumption and caffeine consumption may have detrimental effects during this period. Numerous studies in adolescents (1-7) and young adults (8-13) have shown that past and current calcium intake make a significant contribution to skeletal mass, while some have shown equivocal or no demonstrable beneficial effects (14-18). Exercise, similarly, has shown positive effects in teenagers (4,7) and young adults (9,10,13) in some but not all (14,16-18) studies. These topics have been the subject of recent extensive literature reviews which conclude that both calcium intake and physical activity are important for the development of optimal premenopausal bone mass (19-22).

Broad based national surveys conducted from the 1970's, 1980's and 1990's have consistently demonstrated that females of all ages, races and ethnic groups in the United States consume less than the recommended daily allowance (RDA) of calcium (23-26). There is much less information on the level of exercise and

on smoking, alcohol intake and caffeine consumption in women in the 18-40 year old age group in this country. Furthermore such information has not, to our knowledge, been collected in active duty military women. There is reason to believe that active duty military women may differ from the general population, although there is no data to confirm this impression. Potential areas where differences may occur, at least in some military women, include living accommodations, dietary habits, smoking and alcohol habits, level of physical activity and exercise, participation in field training exercises, deployments and frequent moves. One recent study has suggested that active duty military women may have an increased risk of stress fractures and that smoking, amenorrhea and a family history of osteoporosis may be significant risk factors (27).

In this study, questionnaires were mailed to 3692 active duty premenopausal women selected randomly from personnel files. Questionnaires were approximately 2 pages long and asked questions regarding daily and weekly intakes of specific high calcium foods and calcium supplements, performance of specific aerobic and resistive exercises, and daily quantity of smoking, consumption of alcoholic beverages and consumption of caffeine containing beverages. Participants were asked to return their completed questionnaires to the investigators who tabulated the data in order to determine the mean levels, ranges, standard deviations and standard errors of the study variables.

A subset of 100 participants who were stationed at nearby

installations were recruited to participate in a bone density study. All subjects had blood drawn for a CBC and measurement of serum calcium, phosphorus, chloride, alkaline phosphatase, PTH and TSH and had their bone density measured in the lumbar spine, femoral neck, mid-radius and distal radius by dual energy X-ray absorptiometry (DEXA). Site specific bone density values were then correlated with the various skeletal health factors elicited on the questionnaires with standard multiple regression analyses. Exclusion criteria included any history of hyperparathyroidism, hyperthyroidism, liver, renal or bone disease, or medication use affecting bone metabolism.

Body

A total of 3,692 questionnaires were mailed to active duty women in the continental United States. Of these, 398 questionnaires were returned as undeliverable. Of those delivered, the targeted 1000 have been returned for a response rate of 30.4%. Prior to mailing, the questionnaires were screened by ten individuals to ensure that the questions and formats were easily understandable. In addition, the questionnaires were validated by personal interviews with the 100 individuals included in the subset of volunteers to undergo further study as described above. These individuals also underwent a physical examination including body fat content determination using skin caliper measurements. Approval was also received to further test these individuals body fat content using bioelectrical impedance which was measured after the individuals signed a separate consent form. A second questionnaire was also completed by these individuals asking them to recall calcium intake, personal habits, and physical activity levels during their high school years.

Data from the 1000 returned is included in Table 1. The mean calcium intake of these active duty women was 781 mg which is 219 mg below the current recommended daily allowance (RDA) of 1000 mg per day for premenopausal women. This, however, significantly exceeds the mean intake of 574 mg/day found for all women in the United States in the recent NHANES study (28). Twenty-four percent of our military women equalled or exceeded the RDA of

1000 mg/day.

Demographic data from the 90 individuals who completed bone density testing is shown in Table 2. Table 3 shows data from the bone density determinations. The statistical analysis showed that height correlated with peak bone mass at L2-4 and at the mid-radius. Weight correlated with peak bone mass at L2-4 and at the femoral neck. Both of these findings are consistent with multiple previous studies. Of further interest is the fact that the mean calcium intake dropped by nearly 350 mg/day from high school to the present ($p=<0.001$). Also of note is the fact that present calcium intake correlated well with high school intake ($r=0.58$, $p=<0.005$). No correlation was found between calcium intake and bone density at any site for the group as a whole. We were further interested to see whether by selecting those individuals who maintained their calcium intake after high school, as opposed to decreasing it, might be a subset who would have higher bone densities. We therefore calculated the percent change in calcium from high school to the present and then correlated this with bone densities at L2-4 and the femoral neck. No correlation could be found, however, using this technique (L2-4 $r=0.01$, p=ns; fem. neck $r=0.07$, p=ns).

Reported exercise included time per session, sessions per week, and years of exercise. Using METS estimates for specific activities from standard tables, total METS completed were calculated for each individual. These estimates were then correlated with bone density at the three sites of L2-4, femoral

neck and mid-radius. No significant correlation, however, was found at any sites for high school or present exercise level.

Data concerning consumption level for tobacco, alcohol and caffeine were also tabulated from the questionnaires. Again correlations were made for both high school and present levels with bone density at the three sites. No significant relationship was found at any site.

## Conclusions

From 1000 returned questionnaires data on calcium intake and basic demographic data were tabulated on premenopausal active duty women creating a data reference for this group. Ninety women who comprised a subset of the above were further evaluated with high school diet, habit, and physical activity histories, physical examination, laboratory and bone density determinations. It is apparent from the analysis of this subset that the mean calcium intake in young military women is significantly lower than the RDA of 1000 mg/day: only 24% of the group equalled or exceeded the RDA. Furthermore, there was a significant decline in calcium intake between high school and their young adulthood years. Calcium intake in young adulthood, however, was found to reflect dietary habits learned in high school. Thus the mean calcium intake for young military women is higher than the average for women in the United States but still suboptimal compared with the RDA of 1000 mg/day. Although calcium intake in adolescence has been shown in some studies to be an important factor in achieving and maintaining peak bone mass, data from this study did not show that calcium intake, for women in the 18-40 age group, correlated with bone density at any site.

Additionally, exercise levels for high school and the present and tobacco, alcohol and caffeine usage for that same period could not be shown to be significant factors in achieving higher peak bone mass in this group. These data support the conclusions of others that genetics is the major determinant of

peak bone mass and that its effects far outweigh the measurable effects, if any, of calcium intake, exercise and adverse habits. Nonetheless, because other recent studies have suggested a small but important role for these modifiable risk factors it still seems prudent to recommend adequate calcium intake, regular exercise and moderation in abstinence from tobacco, alcohol, and caffeine.

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CALCIUM STUDY

TABLE 1 - DATA FROM 1000 RETURNED QUESTIONNAIRES

| | Mean | Range | SD | SE | n |
|---|---|---|---|---|---|
| Ca intake (mg/d) | 781 | 0-3700 | 507 | 16 | 1000 |
| Ca+ supp. (mg/d) (years) | 64 | 0-3300 | 222 | 7 | 1000 |
| Age | 29.4 | 18-49 | 6.07 | 0.2 | 1000 |
| Menses (age) | 12.8 | 8-19 | 1.65 | 0.05 | 914 |
| Pregnancies (term) | 0.8 | 0-7 | 1.09 | 0.06 | 916 |
| Tobacco usage (pk/wk) | 0.9 | 0-14 | 2.32 | 0.7 | 1000 |
| Alcohol consumption (oz/wk) | 1 | 0-18 | 1.8 | 0.06 | 998 |
| Caffeine intake (serv/wk) | 15.8 | 0-140 | 17. 0 | 0.5 | 1000 |
| | Caucasian | Black | Hispanic | Other | |
| Race (%) | 67.5 | 22.1 | 5 | 5.3 | 994 |
| | Married | Not married | | | |
| Marital status (%) | 54.7 | 40 | | | 992 |

CALCIUM STUDY

TABLE 2 90 INDIVIDUALS BONE DENSITY MEASURMENT

DEMOGRAPHIC DATA

| | Mean | Range | sd | se | n |
|---|---|---|---|---|---|
| Age (yrs) | 30.4 | 21-39 | 4.9 | 0.52 | 90 |
| Ca intake high school (mg/day) | 1120 | 140-2755 | 526 | 57 | 85 |
| Ca intake (mg/day) present | 822 | 180-2932 | 477 | 50.3 | 90 |
| Height (in) | 65.5 | 59.3-71.6 | 2.58 | 0.27 | 90 |
| Weight (lbs) | 143 | 92-188 | 19.7 | 2.07 | 90 |
| % body fat (B.I.) | 27 | 14-37 | 5.7 | 0.6 | 90 |

| Race | n | % |
|---|---|---|
| Caucasian | 75 | 83.3 |
| Black | 10 | 11.1 |
| Hispanic | 3 | 3.3 |
| Other | 2 | 2.2 |

CALCIUM STUDY

TABLE 3 - PEAK BONE DENSITY

| gm/cm2 | Mean | Range | SD | SE | n |
|---|---|---|---|---|---|
| L2-4 | 1.272 | 1.037-1.711 | 0.138 | 0.0145 | 90 |
| Fem. neck | 1.075 | 0.761-1.403 | 0.13 | 0.0137 | 90 |
| Mid-radius | 0.709 | 0595-0.859 | 0.053 | 0.0056 | 90 |

CALCIUM STUDY

TABLE 4

| | L2-4 correlation coefficient | p value | FEM. NECK correlation coefficient | p value | MID-RADIUS correlation coefficient | p value |
|---|---|---|---|---|---|---|
| Age | -0.02 | ns | -0.17 | ns | 0.24 | 0.03 |
| Height | 0.21 | 0.05 | 0.06 | ns | 0.23 | 0.04 |
| Weight | 0.2 | 0.07 | 0.19 | 0. 08 | 0.15 | ns |
| B.I. | -0.02 | ns | 0.18 | ns | -0.09 | ns |
| Current Ca intake | -0.01 | ns | 0.04 | ns | 0.09 | ns |
| Exercise | -0.05 | ns | 0.08 | ns | 0.07 | ns |
| Caffeine | 0.09 | ns | -0.08 | ns | -0.05 | ns |
| Alcohol | 0.12 | ns | 0.02 | ns | 0.03 | ns |
| Tobacco | 0.19 | ns | 0.22 | ns | 0.09 | ns |
| High school Ca intake | 0.06 | ns | 0.06 | ns | -0.03 | ns |
| Exercise | 0.05 | ns | 0.08 | ns | 0.09 | ns |
| Caffeine | 0.007 | ns | 0.05 | ns | -0.13 | ns |
| Alcohol | 0.0007 | ns | -0.02 | ns | 0.02 | ns |
| Tobacco | 0.09 | ns | 0.2 | ns | -0.21 | ns |